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CRANBERRY DISEASES AND THEIR CONTROL

CRANBERRY DISEASES cause large losses each year. They are due to fungi and abnormal conditions of growth and treatment.

The principal fungous diseases can be prevented largely by spraying with Bordeaux mixture.

The large losses due to smothering can be avoided by proper methods and conditions of picking, storing, and handling the fruit.

Berries should be picked dry or dried quickly, handled carefully, kept in a cool well-ventilated place, and packed preferably in bushel or half-barrel boxes.

Contribution from the Bureau of Plant Industry
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CRANBERRY DISEASES AND THEIR CONTROL.

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DEVELOPMENT OF CRANBERRY DISEASES.

THE AMERICAN CRANBERRY[1] has been in cultivation in this country for nearly a century. Some of the present cranberry meadows have been bearing fruit for 50 years or more. This long-continued growth of the same crop on the same land under the same conditions has favored the development and spread of certain diseases, some of which at present are unknown or rarely found on wild cranberries. These diseases are gradually spreading and becoming more serious.

Wild cranberry plants under natural conditions do not appear to be seriously affected by disease. As is generally the case, however, when a plant is subjected to cultivation and changed conditions and planted over extensive areas, the opportunities for the development and distribution of parasites increase and its diseases become more serious. At the same time the plants under cultivation appear in some cases to become weakened and more susceptible to disease.

The American wild cranberry occurs from Newfoundland southward along the coast and through the Alleghenies to North Carolina and westward along the Great Lakes to Wisconsin and Minnesota. The commercial production of this fruit is at present restricted to a few States, the bulk of the crop being grown in Massachusetts, New Jersey, Wisconsin, Oregon, and Washington.

[1] *Vaccinium macrocarpum.*

The cranberry plant differs greatly from most cultivated plants in its food and water requirements and also in its method of obtaining certain portions of its food. In common with most of the plants of the heath family, it requires an acid soil and obtains part of its nutriment through the aid of a beneficial fungus, known as mycorhiza, which lives in the rootlets. There is much yet to be learned in regard to the best conditions and methods necessary for the production of the most vigorous and healthy cranberry plants. A plant, like an animal, when lacking proper and sufficient food or water becomes weakened and more susceptible to disease than one that is properly nurtured and hardy.

Every cranberry bog differs from every other, and in many cases different parts of the same bog differ in the origin and composition of the soil and in the character and distribution of the soil water and plant food. Experience, careful observation, and study must determine the most satisfactory methods of handling a particular bog in order to obtain the most vigorous, healthy, and productive vines.

SANITARY CONDITIONS.

Much can be done to prevent the development and spread of fungous diseases and increase the vigor and resistance of the vines by carefully regulating the water supply of the bog during the growing season.

Many growers keep the bogs too wet, especially on rich peat bottoms. This tends to produce an excessive growth of vines and favors the fungous diseases. Regular and judicious pruning should be practiced wherever the growth of vines is heavy. The prunings, unless used for planting, should be destroyed by fire in order to prevent the spread of the fungi which soon develop on them and furnish a source of infection for the bog. Rotten fruit discarded in sorting and screening should be buried or otherwise disposed of, so as to prevent the spread of disease.

RESISTANT VARIETIES.

Certain varieties of berries are more susceptible to disease than others. Therefore, in making a new planting varieties which have been found to be most healthy in the locality should be selected where practicable.

Little attention has yet been given to the selection and breeding of resistant varieties. In general, the smaller, firmer fruited varieties are less subject to rot than those bearing larger berries.

The average annual cranberry crop of the United States is about 500,000 barrels, valued at $3,000,000. The total loss from disease

is estimated to average at least 25 per cent, or $750,000 a year. Of this loss about 10 per cent occurs before the fruit is picked and 15 per cent after picking. The losses seem to be greater in the southern localities. The longer summers and higher average temperatures in the South are apparently less favorable to the production of hardy cranberry plants, while they seem more favorable to the development of certain serious fungous parasites.

DISEASES DISCUSSED.

The following diseases will be discussed here. They are arranged in the order of their destructiveness, the worst being presented first. Several others are known, but they are regarded as of no great economic importance at present.

Early-rot (scald, blast, dead-spot, leaf-spot).
Bitter-rot (anthracnose).
End-rot (blossom end-rot, stem end-rot).
Blotch-rot (rot).
Hard-rot.
Tip-blight.
Red-gall.
Rose-bloom (Massachusetts false-blossom, hypertrophy).
Red leaf-spot.
False-blossom (Wisconsin false-blossom, phyllody).
Black-rot.
Rust.

EARLY-ROT.

The name early-rot is applied to the disease caused by a fungus[1] closely related to that producing black-rot of the grape. The different stages and forms of reproduction of this parasite are shown in figure 1. The fungus attacks all of the aerial portions of the plant. The most serious injury is usually caused by the destruction of the fruit, which may be attacked at any time during its development. Under favorable conditions for the growth and distribution of the fungus it attacks the flowers and very young fruits, causing the latter to shrivel and become blackened and finally covered with the spore-bearing pustules of the parasite. This form of the disease has sometimes been called blast and sometimes blight. Blossoms and young fruit frequently fail to develop from other causes, such as imperfect fertilization of the flowers, or from unfavorable weather conditions, such as excessive heat or cold or excessive moisture or drought, or from insects or fungous diseases. Wherever the injury is due to early-rot it is followed by the development of the minute black fruiting bodies of the fungus on the blackened and more or less shriveled young fruit of the cranberry.

The fruit attacked by this disease when half grown or more shows at first a minute light-colored soft spot on the surface. This spot

[1] *Guignardia vaccinii* Shear.

spreads in a concentric manner until finally the whole berry becomes soft and sometimes marked by more or less distinct dark-colored rings. If the rot develops rapidly, however, the berry may show little discoloration. Occasionally the rot is restricted to a small area on the fruit and the tissues become sunken, and sometimes the minute black spore-bearing bodies of the parasite develop. Ordinarily, however, there is no indication on the surface of the fruit of the presence of the parasite except the occasional dark spots or brownish zones.

FIG. 1.—The early-rot fungus: *a*, *b*, and *c*, Fruiting bodies on leaf, stem, and fruit (natural size); *d* and *e*, pycnidium and spores; *f*, *g*, and *h*, perithecium and ascospores (much magnified).

Berries attacked before they are three-fourths grown frequently shrivel or become mummied and blackened and covered with the fruiting bodies of the fungus. This condition is more frequent in New Jersey than in more northern localities, where the disease does not usually make its appearance until the fruit is nearly half grown.

The disease as it affects the nearly grown fruit was formerly called scald, especially in New Jersey. This name had its origin in the belief previously held by many growers that the softening of the fruit caused by the fungus was due to the action of the hot sunshine upon the berries when wet with dew or rain. Occasionally a real scalding occurs on berries which have been overflowed and covered with water for half a day or more during hot weather. Injury of this kind, however, is infrequent and can be distinguished from that caused by fungi by the difference in effect upon the tissues of the fruit. In the case of fungous injury the tissues beneath the skin are mostly destroyed, but the berries remain turgid and elastic under slight pressure. In the case of sun scald, the tissues beneath the light-colored spot are more or less collapsed, or shrunken, or withered, and the spot does not increase in size, as in the case of early-rot.

Occasionally this fungus also attacks the foliage of the plant, causing an irregular reddish brown spot, which may show spore-bearing pustules (pycnidia or perithecia) of the fungus. Usually, however, where the fungus invades the whole leaf it produces no spot, but causes the leaf to drop prematurely. The fruiting pustules of the fungus develop chiefly on the leaves after they have fallen. If cuttings from bogs affected with this disease are planted, the young growth is frequently defoliated by this fungus and sometimes is so seriously injured that the plants die. In old plantings the disease, when very severe, sometimes causes the death of the plants in spots. These are sometimes called dead spots and also, incorrectly, ringworm. The latter name should not be used in connection with fungous diseases, as there is an insect which produces similar dead spots. Where the vines are killed there is no evidence to be found of any injury to the root system by insects or other agencies and the dead foliage of the plants is covered with the fruiting pustules of the early-rot fungus. Sometimes other fungi are also associated with this, tending to increase the injury.

Early-rot is found in all the cranberry-growing sections of the country and is widely distributed on the native wild cranberry plants. It is most prevalent and produces most injury in the southern areas of cranberry cultivation. In the northern areas it appears later in the season and sometimes does not develop until after the fruit has been harvested. Much loss from this disease is caused as a result of dormant infections, which develop and destroy the berries during the period of sorting, packing, shipping, and marketing.

CONTROL.

Experiments conducted by the United States Department of Agriculture and also the experience of various growers during the last 10 years have demonstrated that this disease can be satisfactorily prevented by thorough spraying with 3–3–50 soap-Bordeaux mixture. This mixture should be prepared as follows:

Copper sulphate (blue vitrol or bluestone)	pounds	3
Fresh stone lime	do	3
Water	gallons	50
Commercial resin-fishoil soap	pounds	1

The soap should be dissolved in about 10 gallons of water and added after the lime and bluestone have been mixed. The two requisites for the production of good Bordeaux mixture are fresh stone lime and the thorough mixing of the lime and bluestone solutions. The soap has been found necessary in order to cause the mixture to spread and adhere to the glossy surface of the cranberry fruit and foliage. Where early-rot is serious, at least four applica-

tions of Bordeaux mixture should be made during the season, using 150 to 200 gallons to the acre. The first application should be made just before the flowers begin to open, the second when the blossoms begin to fall, the third two weeks later, and in severe cases a fourth not later than August 15, as later applications are likely to produce a staining of the fruit which may not be washed off before picking.

FIG. 2.—The bitter-rot fungus: *a*, *b*, and *c*, Conidial fructifications; *d*, *e*, and *f*, perithecium and ascospores. (All much magnified.)

BITTER-ROT[1] (ANTHRACNOSE).

This disease is very similar to the bitter-rot of apples and other fruits. The different spore forms and the fructifications of the fungus are shown in figure 2. This fungus attacks both the foliage and the fruit, causing most injury, however, to the fruit. The appearance of bitter-rot on the fruit is not easy to distinguish from several other rots which attack cranberries, and unless the fungus happens to be fruiting on the berries it is usually impossible to determine positively the cause of the rot without making cultures from the tissues of the affected berries or making a careful microscopic examination of the fungus in the interior of the fruit. Affected berries become softened and show more or less of a brownish yellow discoloration.

Bitter-rot is widely distributed and has been found in New Jersey, New York, Massachusetts, Wisconsin, Washington, and Oregon. Its seriousness in any particular locality appears to be closely associated with the weather conditions. Hot weather during July and August appears to be most favorable for its development. The disease usually develops rather late in the season, and frequently not until after the fruit has been harvested.

[1] Caused by *Glomerella cingulata vaccinii* Shear.

CONTROL.

Bitter-rot is somewhat more difficult to control than early-rot. The treatment should be the same as for early-rot, using Bordeaux mixture as recommended and making four applications. Special effort should be made to get the mixture on the vines before a rain. If this can not be done, it should be applied immediately afterwards.

END-ROT[1] (BLOSSOM END-ROT AND STEM END-ROT).

End-rot is a fungous rot of cranberries which has been distinguished from the other rots only within the last few years. It has been found, however, in all the cranberry-growing districts of the United States and has been the cause of considerable loss recently in Massachusetts and Wisconsin. It is called end-rot because, so far as known at present, it always starts at either the blossom or stem end of the berry. Most of the other rots usually start at some other point on the fruit. Aside from the fact that this rot usually begins at the end of the berry, it has no characteristic which makes it distinguishable from some of the other cranberry rots. The fruit when attacked becomes softened and the skin light colored or yellowish. The trouble develops late in the season, especially after picking and packing, and is most common in the northern sections.

CONTROL.

Experiments conducted during the last few years in cooperation with the Massachusetts Cranberry Experiment Station at East Wareham, Mass., have shown that end-rot is reduced by spraying with Bordeaux mixture, as recommended in the regular treatment for early-rot.

BLOTCH-ROT[2] (ROT).

As in the case of some of the other fungous rots of the cranberry, the appearance of the fruit attacked by blotch-rot is not sufficiently distinct for the grower to distinguish it from some of the other rots. The disease is due to the fungus which is shown in the accompanying illustration (fig. 3). This rot first appears as a small, light-colored, soft spot on the berry, finally spreading and destroying the whole fruit. In the later stages of its development it very frequently, though not always, produces small dark-colored blotches in the skin of the fruit. This appearance has suggested the proposed common name, blotch-rot. The only way in which this disease can be positively determined, however, is by making artificial cultures of

[1] Caused by *Fusicoccum putrefaciens* Shear.
[2] Caused by *Acanthorynchus vaccinii* Shear.

the fungus from the diseased berries, a method only available to the plant pathologist. This fungus also attacks the leaves, but it is very rarely found fruiting on them until after they have fallen to the ground.

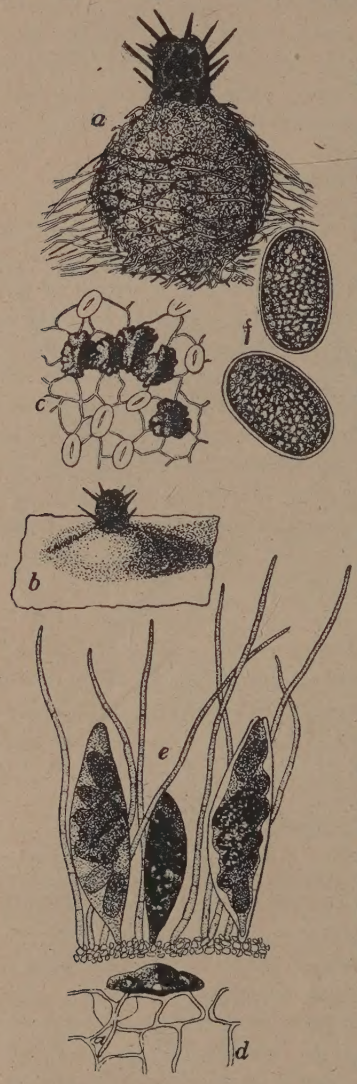

FIG. 3.—The blotch-rot fungus: *a* and *b*, Fruiting bodies; *c* and *d*, organs of attachment; *e* and *f*, asci and spores. (All much magnified.)

Blotch-rot has been found throughout the cranberry-growing sections of the United States and also Nova Scotia. Just how much of the annual loss from rot is due to this disease it is impossible to say, on account of the difficulty of distinguishing it from other diseases. The fungus occurs so frequently, however, in cultures from diseased berries that it is probably one of the common causes of rot.

CONTROL.

Spraying with Bordeaux mixture, as recommended for early-rot, is a satisfactory preventive of this disease.

HARD-ROT AND TIP-BLIGHT.[1]

Hard-rot and tip-blight are forms of a fungous disease caused by an organism closely related to the brown-rot fungus which attacks peaches and other fruits. The first appearance of this disease is to be found on the young growing tips of the plants just before blossoming. The affected tips wilt and dry up, and the gray or white conidia of the fungus develop on them. This is the tip-blight form of the disease.

Later in the season the fungus attacks the fruit, apparently gaining entrance through the blossoms and producing what is termed "hard-rot." The appearance and character of the fruit affected with this disease are well marked and easily recognized when once seen. The

[1] Caused by *Sclerotinia oxycocci* Wor.

affected berries instead of coloring up naturally as they approach maturity become a more or less sordid, pale, yellowish white color, and instead of becoming softened, as in the case of most other fungous diseases, the tissues remain rather firm and leathery. Upon cutting an affected berry through the center the seed cavities will be found to contain a white fungous growth having a cottony appearance. Later in the season such berries shrivel, become darker and harder, and finally become mummied. These mummies contain the sclerotia or resting form of the fungus, which lives over winter. The mature or ascus-bearing form of the fungus has not yet been found on the cranberry, but should be produced from these mummies during the following spring or early summer.

Hard-rot and tip-blight thus far have been found only in Wisconsin and on the Pacific coast. Fortunately, the disease has not yet been very serious. If it should become general it has possibilities of causing much loss, as the affected tips die and bear no fruit and the affected berries are worthless.

CONTROL.

The uncertainty of the occurrence of hard-rot and its scattered appearance have prevented the careful testing of fungicides. From our knowledge of diseases caused by closely related fungi, such as the brown-rot of peaches, plums, etc., there is reason to believe that this disease can be prevented by spraying with Bordeaux mixture. The first application, however, should be made as soon as the new growth starts, in order to prevent the infection of the tips. Further applications should be made as for early-rot.

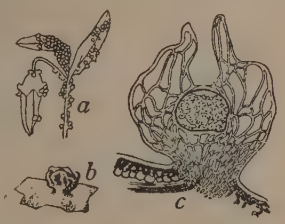

FIG. 4.—The red-gall fungus, showing (*a*) leaves and flower bud affected with galls (natural size), (*b*) enlarged single gall, (*c*) section through a single gall (much magnified), showing the fungus in a circular mass in the center.

RED-GALL.[1]

The red-gall of cranberries is a disease which once seen is very easily recognized. The galls are caused by the fungus shown in figure 4. The disease usually appears just before the blossoms open. The buds, young leaves, and shoots become more or less covered with small, red, somewhat irregular globular galls about the size of bird shot. The affected shoots produce no fruit.

Red-gall is very erratic in its occurrence. The cases thus far observed have appeared on a large number of plants on certain bogs during a particular season and have frequently disappeared the next season. The distribution and development of the parasite seem to

[1] Caused by *Synchytrium vaccinii* Thomas.

depend primarily upon the water conditions of the bog and the amount and distribution of the rainfall. The spores of the fungus are adapted to distribution by water. The affected bogs are usually those which have an excessive water supply or which are uneven and not properly drained. This disease has been found thus far only in eastern cranberry bogs and most frequently in New Jersey.

CONTROL.

The proper grading of the bog and the control of the water supply seem to be the best methods of preventing red-gall. Its uncer-

FIG. 5.—Cranberry rose-bloom, showing the abnormal, flowerlike, enlarged lateral shoots.

tain occurrence and the impossibility of ascertaining its presence until the young galls appear render it impracticable to employ spraying as a means of prevention. Bogs which are properly drained and from which the flood waters are removed early are rarely, if ever, seriously affected with this disease.

ROSE-BLOOM[1] (MASSACHUSETTS FALSE-BLOSSOM, HYPERTROPHY).

Rose-bloom was first observed in Massachusetts and has since been found in the States of Washington and Oregon. It does not appear

[1] Caused by *Exobasidium oxycocci* Rost.

to be widely distributed at present and has proved a serious cause of loss on only a few bogs. Like the red-gall it is rather erratic in its appearance, occurring in abundance one season and perhaps being of little importance on the same bog the next season. It has been found most serious on the Matthews variety in Massachusetts. The disease first makes its appearance on winter-flowed bogs soon after the water has been removed in the spring. The buds in the axils of the leaves of the fruiting shoots, which usually remain dormant, are attacked by the fungus, which stimulates growth, resulting in abnormal lateral shoots bearing enlarged, swollen pink or light rose-colored distorted leaves. The appearance of these shoots is shown in the accompanying illustration (fig. 5). These colored hypertrophied leaves being somewhat crowded together bear a slight superficial resemblance to a flower. This has led to the use of the common names, rose-bloom and false-blossom. The term "false-blossom," however, should be restricted to another disease, to be described later, to which it is more applicable. As this disease usually develops before the blossoms appear, the vitality of the shoot is exhausted and no fruit is produced. Vegetative shoots, or runners, are sometimes attacked also. In such cases, of course, the injury is of less importance. The occurrence of rose-bloom is usually associated with an excessive water supply, which seems to favor its development. Holding the winter flowage until late and reflowing tend to increase the disease when present.

CONTROL.

Early spraying with Bordeaux mixture appears to be helpful in controlling rose-bloom. When the disease is known to occur on a bog the water should be removed earlier in the spring than usual and reflowing avoided if practicable.

RED LEAF-SPOT.[1]

Red leaf-spot is caused by a fungus very closely related to the one producing rose-bloom; in fact, some investigators regard them as merely forms of the same species. The effect upon the plant, however, is quite different. The red leaf-spot, as shown in the accompanying illustration (fig. 6), produces a more or less circular spot upon the leaf and is usually bright red, especially on the upper side. On the lower side the spot is paler and covered with fine spore-bearing filaments of the fungus, giving the appearance of a dense bloom or powder.

This disease has been found in all cranberry-growing sections, but it does not usually cause serious injury to the plants except in

[1] Caused by *Exobasidium vaccinii* (Fckl.) Wor.

Washington and Oregon, where the climatic conditions, especially damp weather, and the luxuriance of growth of the vines appear to furnish unusually favorable conditions for the development and spread of the fungus. That an excess of moisture in the form of fog, rain, or flood is the principal factor in making this a serious disease is indicated by the behavior of this fungus in Massachusetts in 1916. The greater part of that season was unusually wet, and red leaf-spot was much more common than usual. Though the fungi producing rose-bloom and red leaf-spot are so very closely related, the two diseases have been rarely found to occur together. Occasionally they may be found on the same bog, but rarely or never on the same plant.

FIG. 6.—Red leaf-spot of the cranberry.

CONTROL.

Spraying with Bordeaux mixture, as for early-rot, appears to be effective in controlling red leaf-spot, according to the experience of some Pacific-coast growers.

FALSE-BLOSSOM (WISCONSIN FALSE-BLOSSOM, PHYLLODY).

The real cause of the disease known as false-blossom is at present unknown. Studies thus far have failed to show that it is due either to insects or to fungi. It is also uncertain whether it is of an infectious nature. Some observations seem to indicate that the trouble may be caused, in part at least, by unbalanced nutritive conditions. False-blossom has been found chiefly in Wisconsin. The cases which have been found in Massachusetts, New Jersey, Washington, and Oregon appear to have originated, in most instances at least, from plants obtained from Wisconsin.

The chief features of this disease are shown in the accompanying illustrations (figs. 7 and 8). In its simplest form the flower pedicels become more or less erect instead of drooping, the calyx lobes become enlarged and somewhat leaflike, and the petals are short and broad and slightly reddish or greenish in color. The stamens and pistils are more or less aborted and malformed, and affected plants pro-

duce little or no fruit. All intermediate forms and gradations can be found among diseased plants, from the simplest stage, in which there is only a shortening and thickening of the parts of the flower, to cases in which the entire flower is replaced by a short branch with small leaves, as shown in figure 8, *d* and *e*. Affected plants also show a marked tendency toward the development of abnormal terminal buds and of lateral branches arising from the usually latent axillary buds. Such branches are slender and weak and fail to produce normal flowers or fruit. They give the plant a kind of witches'-broom appearance, as shown in figure 7.

This trouble is usually associated with extreme wet or dry conditions of the bog, but most frequently with an excessive water supply. In most of the localities in which it has been observed the affected plants were growing in a deep, coarse peat soil having an excessive water supply during the greater part of the growing season.

FIG. 7.—False-blossom of the cranberry, showing the witches'-broom form due to the abnormal development of axillary buds.

CONTROL.

In the absence of more definite knowledge of the exact cause of false-blossom it is impossible to recommend satisfactory methods of prevention and control. The best conditions possible for normal growth should be provided, especially good drainage, clean culture, and pruning. Where a large number of the plants in a bog are affected with false-blossom it would probably be best to remove and burn the diseased plants and to replant with healthy vines. To prevent the further introduction and spread of the disease only vines known to be absolutely free from false-blossom or coming from localities free from the disease should be used in planting.

BLACK-ROT.[1]

Black-rot develops chiefly in fruit after picking. The affected berries become very dark colored and softened. The fungus causing

[1] Caused by *Ceuthospora lunata* Shear.

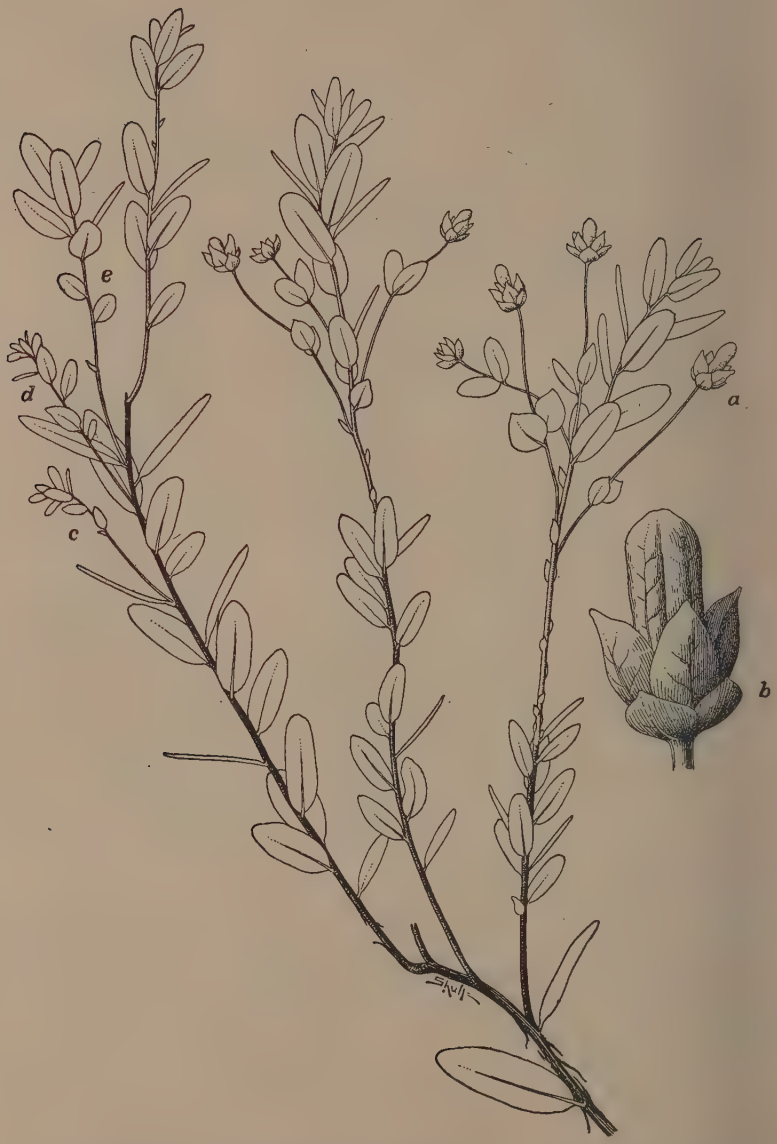

FIG. 8.—False-blossom of the cranberry, showing various abnormal developments of the flowers: *a* and *b*, Floral parts changed to greenish leaflike bodies; *c*, *d*, and *e*, floral parts changed to leafy shoots.

this disease has also been found on dead and dying leaves, but has not caused much injury. It has been found most frequently on fruit from Massachusetts and New Jersey.

CONTROL.

Bogs which have been thoroughly sprayed usually show little of this trouble, and its development can be largely prevented by proper conditions of storage and handling of fruit, as mentioned on page 18.

RUST.[1]

This disease has thus far been observed only in the cranberry bogs on the Pacific coast and has caused no serious injury; but if it should develop in an epidemic form, as is possible, it might do considerable harm to cranberries. It is caused by one of the rust fungi, which forms minute yellowish powdery pustules on the under side of the leaves.

The early spore stage of this fungus develops on hemlocks, and on the Pacific coast will probably be found upon the western hemlock. The disease is likely to occur, therefore, in the East or the West, wherever hemlock is found near cranberry bogs.

CONTROL.

If the rust should prove sufficiently serious to justify the expense, it could probably be controlled by the removal of the hemlocks in the vicinity of the cranberry bogs, if this should seem practicable.

ROT AND SPOILAGE DURING STORAGE, SHIPPING, AND MARKETING.

Until recently the losses from fungous diseases which occur after the crop is harvested have been more or less overlooked and neglected. In the case of the cranberry, the losses after picking are frequently much more serious than those occurring before harvest. These losses are due chiefly to two causes: Fungous parasites which have infected the fruit before picking but have remained in a dormant condition and the smothering or killing of the fruit by lack of ventilation.

By observation and investigation it has been found that about one-half of the loss of berries after picking is due to fungi. The most frequent and important of these fungous rots in recent years have been the early-rot and the end-rot. The development of these rots after picking depends largely upon the conditions under which the fruit is kept and the methods of handling. Where experience

[1] Caused by *Pucciniastrum myrtilli* (Schum.) Arth.

has shown that serious losses occur after picking, spraying should be practiced, as recommended for the control of these rots, as this will prevent largely the infection of the fruit which occurs before picking and thus greatly reduce the losses which develop after picking.

The fruit should be picked dry or dried very quickly after picking, as cranberries which are stored when wet rot more quickly than dry fruit. Great care should be used in handling the fruit. Even slight bruises greatly increase the amount of rot. The berries should be run through the separator only once. In sorting or screening, squeezing the berries should be avoided, and in running berries into barrels or boxes some sort of easer should be used to break the fall and prevent bruising.

The temperature under which the fruit is kept is a very important factor in determining its keeping quality. High temperatures greatly favor the development of fungous rots. As the fruit is usually warm when picked it should be placed in the shade and cooled as rapidly as possible. The storehouse should be well ventilated at night and closed as far as possible during the day, when the outside temperature is usually higher than that inside. In sorting or screening the fruit in cold weather the berries should be kept in a warm room as short a time as possible and packed in a cool room.

SMOTHERING.

Besides the fungous rots, a large amount of spoilage of stored fruit is due to the premature death of the berries and the physical and chemical changes which follow. Such fruit becomes somewhat softened throughout, discolored, and practically worthless. Upon cutting open such berries it will be found that the interior is red and juicy and its natural flavor gone. The cranberry, when picked, is a living organism, carrying on active life processes which are continued under ordinary conditions for a considerable time after the fruit has been removed from the vines. In order to keep the fruit it is necessary to prolong as far as possible these life processes and prevent death. The cranberry may be said to breathe in its own peculiar way, and when it is prevented from so doing it suffocates and dies. The more rapid this breathing the more quickly is the fruit spoiled.

In general, it has been found that high temperatures hasten the death of the fruit by smothering. High temperatures and lack of ventilation are the chief causes of smothering. In order to reduce such loss to a minimum the fruit should be cooled as quickly as possible after picking, being set in a shady well-ventilated place either under trees or under a simple roof of boards or canvas. The berries should

never be covered tightly by spreading canvas or oilcloth over piles of boxes unless the weather is cold.

As much as possible of the hauling to the storehouse should be done early in the day, and the house should be so arranged as to cool the fruit quickly and keep it cool. Ventilating should be done at night and the storehouse kept closed as much as possible during the day. In packing cranberries for market ventilated containers are preferable, especially during warm weather. Half-barrel or bushel ventilated boxes have been found more satisfactory than barrels in reducing the losses from rot and smothering during shipping and marketing.

FIG. 9.—A gasoline-engine spraying outfit on two trucks.

SPRAYING.

The conditions under which cranberries are grown and the character of the plants are so different from those which obtain with other fruits that special methods have been found necessary for the most economic and effective application of fungicides and insecticides.

On the small areas sometimes found in Massachusetts knapsack sprayers may be sufficient, and on small bogs with a sufficiently firm bottom a barrel and cart outfit can be used. It is not often practicable to use a team on a bog, not only on account of the very soft bottom but especially because of the injury to vines and fruit. As it is not

feasible to haul a heavy power sprayer over the bog, some other arrangement must be made.

The most generally satisfactory outfit yet devised for the rapid, effective, and economical spraying of extensive areas of bog is a large gasoline engine sprayer with stock-supply tanks mounted on a separate truck, which may be moved to convenient points on the margins of the bog or dams, where water may be pumped directly from the stream or ditch into the mixing tanks. Where the bog is not too large it may be sprayed by hose direct from the pump, moving the outfit about the margin of the bog or dams when necessary. The

FIG. 10.—Device for making Bordeaux mixture. Pulverized bluestone is being dissolved in one compartment and lime in the other, the two solutions running together in the trough below.

spray mixture may then be distributed to various parts of the bog through galvanized-iron pipes arranged about the margin of the bog and across it in such manner that by means of long leads of hose connected at different points all parts of the bog may be reached.

The capacity of the engine, pumps, and tanks will depend upon the area to be sprayed and the number of spray nozzles which can be most effectively used. The following description and illustrations of an outfit used on a large bog in New Jersey will indicate the essential features. Those planning to install a spraying system for cranberries should inspect and study some satisfactory outfit already in

operation in order to learn all the essential details and decide just what is necessary to adapt the system to their particular conditions.

The outfit referred to, with two trucks, engine, pumps, and tanks, is shown in figure 9. A 9-horsepower gasoline engine and a 3-cylinder high-pressure pump are used; also a centrifugal pump to fill the tanks. On the rear truck are two 200-gallon tanks and a mixing outfit. The arrangement for dissolving and mixing the bluestone and lime is shown in figure 10. A quantity of pulverized bluestone sufficient for a tank of spray mixture is placed in one of the vessels, and the necessary quantity of slaked or hydrated lime in the other. These materials are dissolved by pumping water through the hose inserted in the top of each container. The dissolved materials come out of the lateral spouts at the bottom of the vessels and are mixed as they fall into a trough, in the sides of which blocks are inserted

FIG. 11.—A gang of five cranberry sprayers each with a 4-nozzle spray rod.

to cause the more thorough mixing of the two solutions as they run into the spray tank. To provide a continuous supply of spray mixture one tank is being filled while the other is being used. The pumps are connected with hose with galvanized-iron piping, 1 inch or 1¼ inches in diameter, depending upon the length required to reach around the bog. This pipe is placed on posts about a foot high, to prevent rusting, and extends about the margin of the bog and the dams also if necessary.

In the illustration on the title-page the connection of the spray hose to the pipe line is shown; also a hose cart for moving the long leads of hose from one connection to another on the pipe line and for lengthening or shortening the hose according to the needs of the sprayers.

The spray mixture is distributed by a galvanized-iron spray rod with four or five nozzles attached at intervals near one end, as shown

in figure 11. The spray hose is carried from the reel across the bog on a series of short posts with rollers at the top, as shown in the right-hand margin of the illustration.

Two hose reels and two gangs of nine men are used with this outfit. The two gangs under favorable conditions can cover 8 acres an hour, using about 200 gallons of spray material to the acre. The

FIG. 12.—A galvanized-iron spray rod with nozzles attached at equal distances on the under side.

usual maximum area sprayed is 60 acres a day, as some unavoidable interruptions of the work are likely to occur. This general plan can be adapted to any large bog.

Another style of spray rod, shown in figure 12, is used by some growers. This consists of a galvanized-iron pipe with a number of nozzles attached at regular intervals on the under side and carried by two men. This is very satisfactory for medium-sized bogs and fewer men.

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